Synchrotron XRF Analyses of Pimitive Meal Grains From the Antarctic Meteorite QUE94411

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Introduction: The study of individual grains from meteorites can provide information on the conditions in the solar nebula at the time those grains were formed. The Antarctic meteorite QUE94411 belongs to a group of meteorites classified as Bencubbin/CH-like chondrites. It consists of ~70 volt % Fen metal grains, ~20% of which are zoned in Ni, Co, Cr, P and platinum group elements (M. Weinberg et al., 1999). The donation suggests formation by gas-solid condensation in a gaseous region of the early solar nebula 4.5 Gee ago (*e.g.*, A. Meibom et al., 1999; M. Weisberg et al., 1999). In order to preserve the compositional gradients and to prevent reactions with sulfur, the zoned Fe,Ni metal grains must have been isolated from the gas at high temperature [*e.g.*, A. Krot et al., 2000; A. Meibom et al., 2000a,b]. This inference is supported by the observation of volatility-correlated depletions of elements such as Zn and Cu in bulk samples of QUE94411 (J. Zipfel et al., 1998). To learn more about the conditions under which the metal grains in QUE94411 formed, we analyzed two of them for Fe, Ni, Cr, Ga, and Ge.

Methods and Materials: We analyzed a polished slab of QUE94411 kindly provided by T. McCoy (USNM) and a chunk of the IA iron Canyon Diablo (CD6), provided by T. Kirsten (MPI-Heidelberg). X-ray fluorescence analysis was performed using a monochromatic beam of 16.3-keV photons focused to ~15 μm $\times$15 μm. We calibrated the system with a calcium aluminosilicate glass standard. Absolute concentrations in unknowns were obtained iteratively with the NRLXRF software package by adjusting an assumed iron content for each spot analyzed until the sum of the mass percentages of Cr, Fe, and Ni equaled 100. Elemental ratios are generally reliable to within 10% (F.-Q. Lu et al., 1989).

Results: The 50-ng volume of Canyon Diablo analyzed contained 94.7% Fe, 5.2% Ni, 98±15 ppm Ga, and 350±35 ppm Ge. These results are in good agreement with literature values (J. Wasson and X. Ouyang, 1990). The sensitivity of the system can be gauged from relative counting rates: With 10^6 counts in the iron Kα x-ray peak for CD6, we observed 115 and 538 counts due, respectively, to the Ga and Ge Kα x-rays. The spectra used to obtain the results reported below all had at least 1.5×10^7 counts in the iron Kα peak.

Two metal grains from QUE94411 were analyzed. Grain 1, an ellipse nearly ~ 400 μm on the longer axis, is compositionally homogeneous: Cr ~ 0.43; Fe ~ 94.0, Ni ~5.60; Grain 2, ~100 μm across, is compositionally zoned [center/rim: Cr, 0.16/0.23; Fe, 92.0/96.3, Ni, 7.67/3.34]. The upper limits on the Ga and Ge concentrations in all analyses were ~4 ppm, much lower than expected for metal grains in typical stony meteorites.

Conclusions: At a total pressure of 10^{-4} bar in a cooling solar nebula, Ga and Ge would have condensed at 918 K and 825 K, respectively (H. Palme et al., 1988). The low concentration limits on Ga and Ge therefore suggest that either 1) metal grains condensed from a gas initially depleted by a factor of 10 or more in Ga and Ge, an explanation that does not account for the absence of sulfidization; or 2) the zoned metal grains were chemically isolated from the solar nebula gas prior to condensation of Ga and Ge, i.e., at temperatures above 900 K.

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